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Issued October 15, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 257.

B. T. GALLOWAY, *Chief of Bureau.*

THE WEED FACTOR IN THE CULTIVATION OF CORN.

BY

J. S. CATES,
Assistant Agriculturist,

AND

H. R. COX,
Agriculturist,
Office of Farm Management.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 18, 1912.

Sir: I have the honor to transmit herewith a manuscript entitled "The Weed Factor in the Cultivation of Corn," prepared by J. S. Cates, Assistant Agriculturist, and H. R. Cox, Agriculturist, in the Office of Farm Management, and to recommend its publication as Bulletin No. 257 of the Bureau of Plant Industry.

This manuscript reports the results of 125 experiments conducted for the purpose of determining the relation of weeds to the tillage requirements of the corn crop. These results show comparative yields of corn on one set of plats under the most approved methods of cultivation and on another set with no cultivation whatever, the weeds being eliminated, however, by surface scraping with a hoe. This work seems to involve a fundamental point and sheds considerable light on the subject of tillage.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—757.

THE WEED FACTOR IN THE CULTIVATION OF CORN.

INTRODUCTION.

Corn is one of the most important crops in the United States. Cultivation is one of the most expensive operations in the production of corn. It is also the operation which, of all phases of corn growing, has probably received the least study or about which we have the least fundamental knowledge.

The soil-mulch theory of tillage has been a fundamental one in American agriculture. It was long ago found that by means of a mulch crops could be grown in alternate years on land receiving such scant rainfall as to make it impossible to grow any satisfactory crop by other methods. In studying the effect of the mulch it has come to be generally recognized that in most soils moisture can be saved by maintaining the top portion of the soil in a finely divided condition. It has also been found that frequent stirring of the soil promotes rapid nitrification. It would seem to follow naturally that a system of cultivation which promotes nitrification and conserves moisture would be an extremely valuable system to apply to a tilled crop. In practice it has been found that in most cases frequent shallow cultivation gives better yields than other methods of corn tillage. Upon this experience tillage philosophy has been developed and tillage practice based.

In this publication data are presented with reference to the weed factor in corn cultivation. A direct comparison has been made between what is considered the ideal method of cultivation for corn in each section in which the experiment was conducted and simply removing the weeds without stirring the soil or producing a mulch. The measure of the relative merits of the two systems has been, not in the preservation of soil moisture, or the effect on nitrification, or the making available of plant nutrients, but the relative yields of corn produced.

Experiments aggregating 125 scattered over 28 States are here recorded. Of this number 12 have previously been recorded in experiment-station literature. A study of the results obtained in these 12 early experiments made it seem desirable to take up in a

broad national way the subject of the relation of weeds to the cultivation of corn. Consequently, in the year 1906 a circular letter was sent to the different agricultural experiment stations in the United States giving a general summary of the results already secured and inviting them to cooperate in carrying on simultaneously, through a wide range of soils and climatic conditions, an experiment as outlined to test the relative merits of the mere removal of weeds as compared with supposedly ideal cultivation. A list of graduates of agricultural colleges who are engaged in farming in the various States, together with a number of reliable farmers not coming under that classification, was compiled, and these men were also invited to cooperate with the Department of Agriculture in carrying on the test. The results of these experiments are given in the following pages.

In the tables presented in this bulletin the yields of the uncultivated but weeded plats are expressed in percentages of the cultivated plats, both for fodder and for grain. In the precipitation columns of the tables are given, first, the actual rainfall for a 12-month period, including the last three months of the previous year and the first nine months of the current year, then the mean annual rainfall, and finally the percentage of the actual rainfall expressed in terms of the mean. The records of the weather station nearest to each point where the experiments were conducted or of the station where conditions are most comparable were taken. The columns containing the remarks on soils and climatic conditions give the observations of each of the cooperators covering these points. The headings of the other columns of the tables are self-explanatory.

METHOD OF CONDUCTING THE EXPERIMENTS.

The early tests of five agricultural experiment stations covering the relation of weeds to the tillage requirements of corn were all conducted as a part of a series of experiments on the depth of cultivation. All of them had plats of deep and shallow cultivation, and some had medium-tilled, "standard"-tilled, and mulched plats. The non-tilled plats were referred to as having been "hoed" or "scraped" in all the experiments except those in Utah, where they were "scarified" with a scuffle hoe.

In the work conducted by the Department of Agriculture, beginning in 1906, an outline was furnished each cooperator describing in detail how the test should be made. The salient points in the outline were as follows: A piece of land of very even productivity was to be selected; preparation for planting was to be made by thorough breaking and harrowing and the planting was to be done by drilling on level land—that is, without ridges.

The size of the plats was left to the cooperator. In the work from 1906 to 1910 the plats consisted for the most part of five rows each, making with the one intermediate row which was discarded at harvest, 11 rows in the experiment. In the work of 1911 most of the experiments were conducted on four plats of five rows each, with three intermediate rows, one between every two plats, which were discarded at harvest. The length of the plats varied with the convenience of each man, the average length being about 250 feet.

After planting, one plat or series of plats was to receive absolutely no cultivation, the weeds and grass being removed at frequent intervals

FIG. 1.—Typical appearance of the soil on a cultivated plat of corn.

by means of a sharp hoe. This hoe was to be used with a horizontal stroke to cut off the vegetation at the soil surface, and particular care was to be paid not to stir the soil any more than was absolutely necessary. The other plat or series of plats was to receive the ordinary cultivation and in addition to have the weeds and grass removed by chopping so as to eliminate the weed factor. Figure 1 shows the typical appearance of the soil on a cultivated plat and figure 2 on an uncultivated plat when the plants had reached the tasseling stage. These illustrations show the tests at the Arlington Experimental Farm on a stiff clay soil where the surface of the uncultivated plats was nearly as dry and hard as a floor.

The cooperators entered into the work with enthusiasm, and as a rule the tests were well conducted. Many experimenters were visited each year by a representative of the Bureau of Plant Industry, who advised with them on the subject. At the completion of the tests detailed statements of the various phases of the experiment were reported on special blanks furnished by the Department. Some of the reports were incomplete or indicated that the work had not

FIG. 2.—Typical appearance of the soil on an uncultivated plat of corn.

been properly carried out. All such were discarded in the final compilations.

EARLY EXPERIMENTS IN CORN CULTIVATION.

Probably the first agricultural experiment station, at least in this country, to take note of the weed factor in cultivation was the New York State station, at Geneva. The results are presented in the annual report of that station for 1886. Sturtevant in discussing these results says:

> If this experiment has a meaning, it is that cultivation is not beneficial to the corn plant except so far as removing the weeds is concerned. Strangely enough, we have during the existence of the station been unable to obtain decisive evidence in favor of cultivation.

The next station to take up this study was Illinois. Under the direction of Morrow and Hunt the work was begun in 1888 and continued until 1893; it was taken up again in 1896, thus covering seven years.

In 1889 and 1890 the Missouri Agricultural Experiment Station made investigations on the depth of cultivation and included plats that were weeded but not cultivated. These experiments included the effect of the treatments on soil moisture for the year 1890. This work was started by Sanborn, who, upon his retirement to become director at the Utah station, started the same kind of work at the latter place.

In 1898 and 1899 the South Carolina station made tests of various methods of planting and depths of cultivation, and included a plat that was weeded but not cultivated.

The results of all these experiments, with the exception of those in Utah, are shown in Table I.

TABLE I.—*Results of early experiments in corn tillage.*

Location of State experiment station.	Year.	Yield per acre.				Yield of uncultivated plat expressed as percentage of cultivated.		Precipitation.		
		Cultivated plats.		Uncultivated plats.				For last 3 months of preceding and first 9 months of current year.	Mean.	Comparison with mean.
		Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.			
		Lbs.	*Bush.*	*Lbs.*	*Bush.*			*Inches.*	*Inches.*	*Per ct.*
Geneva, N. Y.[1]	1886	.....	56.8	.....	70.5	.....	124.1	32.66	32.81	99.5
Urbana, Ill.[2]	1888	.....	93.8	.....	90.0	.....	95.9	40.11		112.2
	1889	.....	84.6	.....	77.1	.....	91.1	41.74		116.7
	1890	.....	66.8	.....	69.1	.....	103.4	39.16		109.5
	1891	.....	58.4	.....	55.3	.....	94.7	25.09	35.74	70.2
	1892	.....	70.1	.....	76.8	.....	109.5	42.70		119.4
	1893	.....	36.3	.....	28.7	.....	79.0	37.72		105.5
	1896	.....	85.5	.....	87.0	.....	101.7	40.00		111.9
Columbia, Mo.[3]	1889	3,920	80.1	3,900	82.0	99.5	101.3	42.34	38.46	110.0
	1890	2,205	54.0	1,570	45.7	71.2	84.6	40.86		106.2
Clemson College, S. C.[4]	1898	.....	58.6	.....	56.5	.....	96.4	48.35	51.14	94.6
	1899	.....	67.3	.....	67.5	.....	100.3	50.11		98.0
Total	.....	6,125	812.3	5,470	806.2	.....	.....	480.84	.....	.....
Average	.....	3,062	67.69	2,735	67.18	85.35	98.5	40.07	38.51	104.4

[1] Annual Report, 1886, p. 46.
[2] Illinois Bulletins 20, 25, 31, 46.
[3] Missouri Bulletin 14.
[4] South Carolina Bulletin 61.

EXPERIMENTS IN UTAH.

Table II shows the results of seven years' work covering experiments on corn cultivation made at the Utah Agricultural Experiment Station, as recorded in Bulletin No. 66 of that station. As these experiments were made under irrigation conditions, the data are not included in the discussions of the other early experiments or in the résumé on page 24. It is apparent that the "no tillage" treat-

ment did not receive a fair trial, since, to quote the bulletin mentioned, page 129, "the weed pulling by hand loosened the soil to a considerable extent, for they were not pulled until large enough to be easily taken hold of, and they were always plentiful." In a recent letter Prof. Sanborn describes the treatment of the "scarified" plats, showing that it was practically identical with the nontilled treatment of our work. In this connection, therefore, the scarified plats should be compared with either the shallow-tilled or medium-tilled plats.

It will be noted in Table II that the average figures of all the years for the scarified plats is 58.87 bushels of grain and 3,036 pounds of fodder, as compared with 52.91 bushels of grain and 3,487 pounds of fodder for the shallow-tilled plats and 57.31 bushels of grain and 3,431 pounds of fodder for the medium-tilled plats.

TABLE II.—*Results of experiments in corn tillage in Utah.*

Year.	Yield per acre.											
	Shallow tillage.		Medium tillage.		Deep tillage.		No tillage.		Mulched with dirt.		Scuffle hoe (scarified).	
	Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.
	Pounds.	*Bush.*	*Pounds.*	*Bush.*	*Pounds.*	*Bush.*	*Pounds.*	*Bush.*	*Pounds.*	*Bush.*	*Pounds.*	*Bush.*
1890 1892 [1]	1,704	16.75	1,981	15.80	1,169	27.08	1,574	12.35	1,270	16.69	2,286	23.10
1893	1,666	37.52	2,433	54.18	2,866	61.11	2,933	67.23	2,844	76.18	2,000	43.60
1894	2,800	51.81	3,467	69.22	3,067	52.76	3,600	52.38	3,067	56.38	2,800	57 33
1895	.....	57.14	.....	54.09	.....	50.67	.....	63.43	.....	60.75	.....	72.19
1896	8,067	79.04	6,606	75.14	9,600	66.66	6,227	71.05	8,160	76.57	4,360	69 33
1897	3,200	75.22	2,667	75.41	1,867	79.41	2,667	44.75	3,467	48.75	3,733	77.69
Average	3,487	52.91	3,431	57.31	3,714	57.45	3,400	51.86	3,762	55.89	3,036	58.87

[1] Average for the two years.

EXPERIMENTS OF THE BUREAU OF PLANT INDUSTRY.

In 1905 the senior writer collected the early data of the State agricultural experiment stations and conducted a test on corn cultivation at Ithaca, N. Y. On becoming a member of the staff of the Department of Agriculture he carried on similar tests in 1906 in cooperation with three experiment stations and in 1907 with four stations, one individual, and the Arlington Experimental Farm of the Department. In 1908 the work was conducted by four stations, one individual, and the test farm at Arlington. In 1909, 1910, and 1911 it was carried on in cooperation with various farmers in different parts of the United States.

Figure 3 shows the shocked corn from the plats at the Arlington Experimental Farm in 1908. One of the shocks is from a cultivated plat, the next one from an uncultivated plat, and thus alternating through the series. Figure 4 shows the ear corn from the same

experiment, one pile being from a cultivated plat, the next one from an uncultivated plat, and thus alternating. Figure 5 illustrates the

FIG. 3.—Shocks from the corn experiment at the Arlington Experimental Farm, 1908. The shock at the right is from a cultivated plat, the next one from an uncultivated plat, and so on.

experiment of Mr. J. J. Lee, Cynthiana, Ky., in 1909, showing the uncultivated plat and the cultivated plat. Figure 6 shows the

FIG. 4.—Ears of corn from the same shocks shown in figure 3. The corn at the left was cultivated, that in the next pile uncultivated, and so on.

fodder and ear corn from the experiment of Mr. Geoffrey Morgan, Whites Station, Ky., in 1910, both cultivated and uncultivated.

FIG. 5.—Cultivated and uncultivated plats of corn, the experiment of Mr. J. J. Lee, Cynthiana, Ky., in 1909. The uncultivated plat is shown in the left half of the illustration and the cultivated plat on the right.

FIG. 6.—Cultivated and uncultivated fodder and ears of corn, the experiment of Mr. Geoffrey Morgan, Whites Station, Ky., in 1910. The cultivated fodder and corn are at the left of the illustration and the uncultivated at the right.

Figure 7 represents one of the three pairs of uncultivated and cultivated plats at Arlington in 1911, photographed just before tasseling.

A number of experiments were carefully conducted up to a certain point and were then discontinued for various reasons, such as stock

FIG. 7.—One of three pairs of corn plats at the Arlington Experimental Farm in 1911. The uncultivated corn is at the left and the cultivated at the right.

breaking in, storms blowing down the corn, or the plats being harvested together by mistake. Of 15 such discontinued experiments 8 showed practically no difference between the cultivated and uncultivated plats at the time of the discontinuance; 4 were in favor of the uncultivated and 3 in favor of the cultivated treatment.

Table III gives the data for the seven years 1905 to 1911.

TABLE III.—*Results of experiments in corn tillage for the years 1905 to 1911, inclusive.*

Name and address of experimenter.	Year.	Yield per plat.				Yield of uncultivated plat expressed as percentage of cultivated.		Size of plat.	Yield per acre (calculated).				Precipitation.			Remarks.
		Cultivated.		Uncultivated.					Cultivated plats.		Uncultivated plats.		Last 3 months of preceding and first 9 months of current year.	Mean.	Comparison with mean.	
		Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.		Fodder.	Grain.	Fodder.	Grain.				
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*			*Acres.*	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Ins.*	*Ins.*	*P. ct.*	
Cates, J. S., Ithaca, N. Y.:																
Plat 1	1905	33	35	29	32	87.8	91.4	.....	.....	.....	.....	.....	35.05	32.97	94	Rolling land.
Plat 2	1905	29	28	26	28	89.6	100	.....	.....	.....	.....	.....	.....	.....	.....	Level land.
Michigan experiment station, East Lansing, Mich.	1906	.....	473	.....	535	.....	113.1	.....	.....	.....	.....	.....	28.94	30.99	107	
New Hampshire experiment station, Durham, N. H.	1906	1,960	1,631	2,190	2,310	111.7	141.6	.....	1,960	23.3	2,190	33	39.73	40.67	102.3	
Purdue experiment station, Lafayette, Ind.	1906	.....	370	.....	355	.....	95.9	0.1125	.....	46.97	.....	45.04	38.17	36.83	96.5	
Total	.....	2,022	2,537	2,245	3,260	.....	.....	.1125	1,960	70.27	2,190	78.04	.....	.....	.....	
Average	.....	674	507.4	748.3	652	96.36	108.4	.1125	.....	35.13	.....	39.02	35.47	35.36	99.95	
Arlington Experimental Farm, Rosslyn, Va.:																
Plat 1	1907	.....	104.04	.....	123.76	.....	118.9	.....	.....	.....	.....	.....	44.73	40.80	109.6	Clay soil; planted 3.3 by 3.3 feet.
Plat 2	1907	.....	157.41	.....	134.64	.....	85.5	.....	.....	.....	.....	.....				Gently sloping; planted in rows 3.3 feet apart, half that distance between hills.
Cornell experiment station, Ithaca, N. Y.	1907	.....	3,522	.....	3,643	.....	103.4	.....	.....	50.3	.....	52.0	33.25	32.97	100.7	Rather sandy; rolling.
Froley, J. W., Springfield, Md.	1907	.....	151	.....	165	.....	109.2	.033	.....	65.3	.....	71.3	40.13	41.80	96	
Michigan experiment station, East Lansing, Mich.:																
Plat 1	1907	270	287	243	471	89.6	164.1	.....	.....	.....	.....	.....	33.18	30.99	107	Sandy, gravelly loam; Rustler.
Plat 2	1907	251.7	225	235.6	225	93.6	100	.....	.....	.....	.....	.....				Level; Silver King. Spring cold and wet.

Nebraska experiment station, Lincoln, Nebr.	1907	.....	4,333	.....	4,417	.....	101.9	.....	.....	61.9	.....	63.1	28.41	27.51	103.2	Alfalfa sod; good soil.
Purdue experiment station, Lafayette, Ind.	1907	.....	1,077.5	.....	1,118	.....	103.7	.2	.....	77	.....	79.8	38.44	36.83	104.3	Extremely wet.
Total	.....	521.7	9,856.95	478.6	10,297.4	.....	.....	.233	.....	254.5	.....	266.2	.....	.....	.....	
Average	.....	260.8	1,232.12	239.3	1,287.17	91.6	110.84	.1165	.....	63.6	.....	66.55	36.36	35.15	103.47	
Arlington Experimental Farm, Rosslyn, Va.	1908	197.5	290	186	283.5	94.2	97.7	.10	1,975	41.4	1,860	40.5	42.86	40.80	105	Clay; slightly sloping.
Campbell, J. M., Richardson, Tex.	1908	285	264	251	268	88	101.5	.....	.....	.....	.....	.....	46.39	42.62	108.7	Black waxy soil; level.
Minnesota experiment station, St. Paul, Minn.	1908	270	450	270	450	100	100	.10	2,700	62.5	2,700	62.5	29.99	27.80	107.7	Sandy loam; average season.
New Hampshire experiment station, Durham, N. H.	1908	4,980	4,953	4,860	4,974	97.6	100.4	.....	4,980	67.9	4,860	68.2	43.09	40.67	105.8	
North Carolina experiment station, W. Raleigh, N. C.	1908	.....	808.5	.....	744.1	.....	92	.....	.....	11.55	.....	10.63	61.05	49.47	123.2	Raw, poor, black-jack clay.
Purdue experiment station, Lafayette, Ind.	1908	.....	4,375	.....	4,200	.....	96	.....	.....	62.5	.....	60	33.00	36.83	89.8	
Total	.....	5,732.5	11,140.5	5,567	10,919.6	.....	.....	.20	9,655	245.85	9,420	241.83	.....	.....	.....	
Average	.....	1,433.1	1,856.8	1,391.7	1,819.9	94.95	97.93	.10	3,218	49.17	3,140	48.36	42.74	39.69	106.7	
Anderson, W. B., Velpen, Ind.	1909	(1)	337	(1)	460	.....	136.5	.10	.....	48.1	.....	65.65	35.80	40.77	87.9	Yellow clay, rolling; wet early part of season.
Arlington Experimental Farm, Rosslyn, Va.	1909	445	321	408	238	91.7	74.1	.15	2,966	30.6	2,720	22.7	34.42	40.80	84.4	Stiff clay, packed hard; sloping; period of drought during summer.
Barrett, J. M., Napton, Mo.	1909	(1)	190	(1)	235	.....	123.7	.052	.....	52.2	.....	64.57	39.78	36.50	108.9	Silt loam, level; fairly good season, except 5 weeks dry weather after July 27.
Callison, N. A., Gainesville, Fla.	1909	710	580	680	505	95.8	87.1	.327	2,171	25.3	2,077	22.02	39.73	51.34	77.4	Sandy loam, level; rather dry season.
Campbell, J. M., Richardson, Tex.	1909	.....	214	.....	143	.....	66.8	.250	.....	12.2	.....	8.15	16.18	39.04	41.4	Black waxy, level; very dry season.
Cunningham, T. J., Chester, S. C.	1909	[2] 27	173	27	199	100	115	.096	.....	22.5	.....	25.9	47.99	49.13	97.6	Gravel, clay subsoil; rolling land; wet season.
Day, A. P., West Kennebunk, Me.	1909	[1] 665	.....	[1] 575	.....	86.5	.....	.154	.....	.....	.....	.....	37.36	42.63	87.6	Sandy loam, clay subsoil, sloping slightly; extremely dry season.
Dimond, O. C., West Concord, N. H.	1909	153	166	[3] 186	201	121.5	121.1	.038	4,050	62.4	4,891	75.6	30.14	39.82	75.7	Strong loam; hill land, with gentle slope; rather dry season.
Foster, W. L., Shreveport, La.	1909	(1)	375	(1)	430	.....	114.7	.322	.....	16.6	.....	19.04	29.64	45.45	65.2	Sandy loam, level; wet in early part of season.
Lambert, F. L., Charles City, Iowa.	1909	.....	261	(4)	301	.....	115.3	.066	.....	56.4	.....	65	36.57	31.29	116.8	Sandy loam, level; good season.
Lee, J. J., Cynthiana, Ky.	1909	[4] 555	494	547	474	98.5	96	.0868	6,393	81.3	6,298	78	47.08	43.99	107.2	Dark loam, level; wet season.

[1] No difference in time of ripening. [2] Ripened slightly earlier. [3] Ripened a few days earlier. [4] Ripened earlier.

TABLE III.—*Results of experiments in corn tillage for the years 1905 to 1911, inclusive*—Continued.

Name and address of experimenter.	Year.	Yield per plat.				Yield of uncultivated plat expressed as percentage of cultivated.		Size of plat.	Yield per acre (calculated).				Precipitation.			Remarks.
		Cultivated.		Uncultivated.					Cultivated plats.		Uncultivated plats.		Last 3 months of preceding and first 9 months of current year.	Mean.	Comparison with mean.	
		Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.		Fodder.	Grain.	Fodder.	Grain.				
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*			*Acres.*	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Ins.*	*Ins.*	*P. ct.*	
Leffler, G. V., Stockport, Iowa.	1909	.....	156	.....	171	.....	109.6	0 055	.....	40.5	.....	44.4	32.44	34.97	92.8	Heavy loam, level; rather dry season.
Littlejohn, W. D., Kentland, Ind.	1909	.....	171	(1)	163	.....	95.3	.0331	.....	73.8	.....	70.4	48.08	36.13	133	Black sandy loam, level; wet season.
McCune, Kate B., Shedd, Oreg.	1909	(2)	47	(2)	50	.....	106.3	.0062	.....	107.4	.....	114.2	.....	.....	.....	Clay loam, level; rather dry season.
Merwin, G. H., Southport, Conn.	1909	(2)	540	(2)	540	.....	100	.0984	.....	78.4	.....	78.4	42.20	45.89	92	Heavy loam, level; fairly good season.
Perry, J. B., Clarks Falls, Conn.	1909	1 331	264.5	320.5	287.7	96.8	108.7	.0827	4,002	45.7	3,872	49.6	45.84	46.18	99.4	Light loam, hardpan, gravelly subsoil, level; dry season.
Purdue experiment station, Lafayette, Ind.	1909	.....	2,940	.....	2,947	.....	100.25	.....	.....	42	.....	42.1	46.80	36.83	127	
Rich, E. A. J., Brinson, Ga..	1909	342	309	373	429	109	138.8	.1446	2,365	26.7	2,579	37.04	36.10	49.90	72.3	Sandy loam, level; rather dry season.
Sawyer, R. S., Walpole, N. H.	1909	.....	785	.....	542	.....	69.1	.1572	.....	71.3	.....	49.2	36.77	41.04	89.5	Do.
Seay, Robt., Emporia, Va...	1909	2 160	201	2 169	162	105.6	80.6	.0965	1,658	29 7	1,751	23.95	50.47	45.89	110	Sandy loam, level; dry.
Sugar experiment station, New Orleans, La.	1909	(2)	99.3	(2)	99.3	.....	100	.0602	.....	20.6	.....	20.6	59.23	55.63	106.4	Heavy sandy loam, level; average season.
Tenney, W. P., Chester, N. H.	1909	(2)	425	(2)	725	.....	170.5	.1944	.....	31.25	.....	53.2	30.14	39.82	75.7	Medium to light loam, level; very dry season.
Wallace, M., Marion, S. C....	1909	(2)	2,947	(2)	2,709	.....	91.9	.496	.....	84.9	.....	78	40.24	46.55	86.5	Clay, level; season a little dry.
Watson, D. A., Durham, N. H.	1909	.....	238	.....	236	.....	99.1	.0505	.....	67.4	.....	66.8	33.79	42.17	80.2	Fine clay loam, sloping; season dry and cold.
Welch, E. K., Northwood Center, N. H.	1909	2302	170	2320.5	186.5	106.1	109.7	.0378	.....	64.2	.....	70.4	30.14	39.82	75.7	Sandy loam, gravelly with hardpan subsoil; hilly; season unfavorable.

Wollschlaeger, Gus, Boerne, Tex.	1909	(2)	340	(2)	346	.....	101.7	.253	.....	19.2	.....	19.55	22.26	31.42	70.9	Black waxy, hilly; very dry season.
Total	.....	3,690	12,743.8	3,606	12,779.5	.....	.....	3.4074	23,605	1,210.65	24,188	1,264.83	.....	.....	.....	
Average	.....	369	509.7	360.6	511.2	101.15	105.27	.1363	3,372	48.42	3,455	50.59	37.96	42.13	90.46	
Anderson, W. B., Velpen, Ind.	1910	.....	804	.....	798	.....	99.2	.1285	.....	62.6	.....	62.2	40.47	40.77	99.4	Light clay, level; season very wet.
Bigstaff, T. J., Mount Sterling, Ky.	1910	6,890	2,680	[1] 6,300	2,590	91.4	96.6	1.016	4,145	37.65	3,650	36.39	61.85	48.10	128.0	Clay loam, gently rolling; season very wet.
Brant, W. C., Ruffin, S. C.	1910	[2] 130.75	141.25	[2] 184	135	140.6	95.5	.0287	4,550	70.3	6,408	67.2	47.84	50.02	95.7	Light sandy, level; heavy rains.
Campbell, J. M., Richardson, Tex.	1910	.....	115.7	.....	124	.....	107.1	.0689	.....	24	.....	25.71	27.74	39.04	71.1	Black waxy, level; very dry; less than 4 inches of rain after planting.
Case, J. H., Lawrenceburg, Ky	1910	.....	4,550	(1)	4,900	.....	107.7		.....	65	.....	70	46.03	43.58	105.7	Uniform clay loam, hilly.
Crum, H. C., Denmark, S. C.	1910	(1)	168.7	.....	192.8	.....	114.3	1.1147	.....	21	.....	24	41.09	47.89	85.8	Sandy loam, red clay subsoil; too much rain.
Dailey, S. C., North Baltimore, Ohio.	1910	904	1,347	[3] 872	1,202	96.4	89.2	.2315	3,900	83.1	3,765	74.1	35.18	38.35	91.7	Loose black soil, level; fair season, but dry in August.
Day, A. P., West Kennebunk, Me.	1910	164	146	153	127	93.3	87	.0413	3,970	47.9	3,705	41.7	32.10	42.63	75.3	Clay loam, gently sloping; favorable season.
Dimond, O. C., West Concord, N. H.	1910	[1] 300	274	254	249	84.6	90.9	.0432	6,950	90.6	5,875	82.4	29.59	39.82	74.3	Strong loam, rolling; wet early; dry late.
Elmer, E. O., Devereaux, Mich.	1910	[2] 68.9	118	[2] 67.9	120.2	98.6	101.8	.0197	3,497	85.6	3,448	87.1	30.83	33.33	92.6	Clay loam, level; wet and cold after planting; very dry during July.
Ferguson, A. M., Sherman, Tex.	1910	.....	86	.....	82.5	.....	95.9	.2169	.....	5.67	.....	5.43	22.09	38.25	57.7	Black waxy, some sand; very dry during growing period.
Finley, W. W., North Wilkesboro, N. C.	1910	.....	392	(1)	362	.....	92.3	.1147	.....	48.8	.....	45.1	46.23	57.63	80.2	Red clay, level; rainy in June, dry in July.
Fredericks, C. P., Sunbury, Ohio.	1910	189	161.2	[4] 168.8	171.4	89.3	106.4	.0459	4,120	50.14	3,680	53.34	33.48	36.68	91.3	Clay loam, level; fair season.
Gardner, E. T., Fowler, Colo.	1910	[2] 144.4	71.8	[2] 128.2	64.7	88.8	90.1	.0632	2,288	16.2	2,032	14.62	.....	12.98	.....	Loam, gently sloping; season dry; one irrigation.
George, H. C., Okeana, Ohio.	1910	.....	1,150	.....	1,035	.....	90	.2963	.....	55.4	.....	49.9	31.98	40.91	78.1	Clay loam; bottom land; season rather wet.
Goddard, W. R., Amesville, Ohio.	1910	.....	360	(1)	336	.....	93.3	.0606	.....	84.9	.....	79.2	29.40	39.37	74.8	Black clay, level; bottom land; very dry season.
Hansbarger, D., Ansonia, Ohio.	1910	(1)	6,060	.....	6,023	.....	99.4	8.22	.....	105.4	.....	104.8	37.06	36.97	100.2	Black, fairly loose soil, level; dry toward last of season.
Hester, H. C., Mayfield, Ky.	1910	[5] 330	250	180	210	54.5	84	.0482	6,850	74.1	3,730	62.2	49.65	48.63	102.1	Loose clay loam, level; no rain till roasting-ear stage; then very wet.
Heuser, W. L., Haymarket, Va.	1910	[2] 102	136	[2] 81	112	79.4	82.4	.0397	2,570	48.9	2,038	40.3	38.54	38.02	101.2	Red shale soil, level; wet early, dry later.

[1] Ripened earlier. [2] No difference in the time of ripening. [3] Ripened 3 days earlier. [4] Ripened 5 days earlier. [5] Ripened a few days earlier.

TABLE III.—*Results of experiments in corn tillage for the years 1905 to 1911, inclusive*—Continued.

Name and address of experimenter.	Year.	Yield per plat.				Yield of uncultivated plat expressed as percentage of cultivated.		Size of plat.	Yield per acre (calculated).				Precipitation.			Remarks.
		Cultivated.		Uncultivated.					Cultivated plats.		Uncultivated plats.		Last 3 months of preceding and first 9 months of current year.	Mean.	Comparison with mean.	
		Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.		Fodder.	Grain.	Fodder.	Grain.				
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*			*Acres.*	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Ins.*	*Ins.*	*P. ct.*	
Howle, P. L., Darlington, S. C.	1910	(1)	78.1	(1)	75.81	.....	97.1	0.0744	.....	15	.....	14.56	39.53	47.20	83.8	Sandy, with clay subsoil; fairly good season.
Huyett, J. B., Charles Town, W. Va.	1910	(1)	323.6	(1)	225.5	.....	69.7	.1398	.....	33.1	.....	23.08	27.52	37.43	73.6	Loam, with clay subsoil; extremely dry season.
Kirkpatrick, L. R., McKinney, Tex.	1910	.....	448.7	(2)	308	.....	68.4	.1687	.....	38	.....	26	27.74	49.96	55.6	Black loam; low bottom, extremely dry season.
Lambert, F. L., Charles City, Iowa.	1910	(1)	213.7	(1)	213.7	.....	100	.0555	.....	55	.....	55	25.04	31.29	80.1	Sandy loam, level; dry at first; wet later.
Lemmon, R. H., Winnsboro, S. C.	1910	(1)	52	(1)	52	.....	100	.0155	.....	47.9	.....	47.9	41.85	44.61	93.8	Sandy loam, slightly rolling; wet season.
Lloyd, F. L., Smithville, Ky.	1910	(2)	62.5	.....	63.5	.....	101.6	.01406	.....	63.5	.....	64.4	48.29	45.67	105.6	Heavy clay, rolling; wet season.
McClelland, C. K., Prescott, Ark.	1910	(2)	64.2	.....	49.7	.....	77.4	.0884	.....	10.37	.....	8.03	47.56	44.94	105.7	Heavy clay, nearly level; very dry most of season.
McCulloch, Fred, Hartwick, Iowa.	1910	77.5	213.5	75	202	96.8	94.6	.....	.....	.....	.....	.....	25.43	34.48	73.9	Season very dry and hot.
McCune, Kate B., Shedd, Oreg.	1910	(1)	13	(1)	12	.....	92.3	.00284	.....	65.2	.....	60.3	.....	.....	.....	Clay loam; season very dry.
Marvin, Jas. A., Hendersonville, S. C.	1910	.....	497	(2)	518	.....	104.2	.297	.....	23.9	.....	24.9	47.84	50.02	95.6	Sandy soil, clay subsoil; latter part of season very wet.
Morgan, Geoffrey, Whites Station, Ky.	1910	[2] 650	705	700	820	107.7	116.3	.1027	6,330	98.1	6,820	114.1	50.22	44.02	114	Loam soil, clay subsoil; very wet season.
Nichols, W. D., Bloomfield, Ky.	1910	177	171	118	126	66.6	73.7	.....	.....	.....	.....	.....	48.39	44.90	107.7	Clay loam, gently sloping; rather dry early, very wet later.
Perry, John B., Clarks Falls, Conn.	1910	[1] 364	320	[1] 368	323	101.1	100.9	.1077	3,376	42.45	3,415	42.82	36.89	46.18	79.9	Light loam, level; good season.
Ratliff, W. S., Richmond, Ind.	1910	126.5	92	114.5	114	90.5	123.9	.0313	4,040	42	3,656	52	37.62	38.49	97.8	Sandy loam, clay subsoil; rather dry season.
Rector, J. H., Cumberland Gap, Tenn.	1910	260	350	[2] 300	330	115.4	94.3	.0358	7,260	139.7	8,380	131.7	44.11	48.33	91.4	Clay soil, level; very wet season.
Rinehart, N. W., Union, Ohio	1910	(1)	545.5	(1)	459.5	.....	84.2	.0745	.....	104.6	.....	88	32.63	36.55	89.4	Rich, black, level bottom.

Ross, Henry, Milford, Mich.	1910	[1] 490	450	[1] 445	445.3	90.8	99	.208	2,353	30.9	2,136	30.6	28.04	31.77	88.3	Clay loam, sloping; season rather dry.
Royse, Oscar, Shenandoah, Iowa.	1910	.....	108.5	.....	120.75	.....	111.2	.0312	.....	49.65	.....	55.25	30.83	32.25	95.6	
Sugar Experiment Station, New Orleans, La.	1910	(1)	258	(1)	295.8	.....	114.7	.1206	.....	30.5	.....	35	55.12	55.63	99.1	Heavy alluvial silt; average season except long drought in spring.
U. S. Plant Introduction Garden, Chico, Cal.	1910	(1)	52.5	(1)	46	.....	87.6	.0603	.....	12.4	.....	10.9	21.84	23.39	93.4	Sandy loam, level; season very dry.
Welch, E. K., Northwood Center, N. H.	1910	[1] 243	187	[1] 329	236	135.4	126.2	.0379	6,410	70.5	8,670	89	29.59	39.82	74.3	Sandy loam, hilly; season rather dry.
Williams, D. W., Wauseon, Ohio.	1910	[1] 850	881	[1] 902.5	888.5	106.5	100.8	.1185	7,174	106.2	7,641	106.9	36.04	37.31	96.6	Clay and sand, good soil; season rather dry.
Winsor, B. E., Coventry, R. I.	1910	(1)	351.5	(1)	315	.....	89.6	.0689	.....	72.9	.....	65.3	33.61	45.31	74.2	Sandy loam, hilly; season very dry.
Wollschlaeger, Gus, Boerne, Tex.	1910	(1)	452	(1)	448.7	.....	99.3	.2712	.....	23.78	.....	23.6	19.73	31.42	62.8	Black waxy, level; season very dry.
Total	.....	12,461	25,901.95	11,740.9	25,523.3	.....	.....	6.525	79,783	2,252.91	79,049	2,195.03	.....	.....	.....	
Average	.....	655.8	602.3	617.9	593.5	96.19	96.51	.1591	4,693	54.95	4,650	53.54	36.99	41.8	88.7	
Anderson, W. B., Velpen, Ind.	1911	(1)	1,040	(1)	1,014	.....	97.5	.20	.....	74.3	.....	72.4	.....	.....	.....	Loose bottom land, level; very wet except in midsummer, when it was very dry.
Arlington Experimental Farm, Rosslyn, Va.	1911	982	824	1,110	608	113	73.9	.15	6,545	78.4	7,400	58	.....	.....	.....	
Brant, W. C., Ruffin, S. C.	1911	910	565	925	590	101.6	104.4	.241	3,775	33.5	3,839	35	.....	.....	.....	Bottom land, level.
Dailey, S. C., North Baltimore, Ohio.	1911	1,200	1,270	[3] 1,160	1,185	96.6	93.3	.471	2,550	38.5	2,460	35.9	.....	.....	.....	
Day, A. P., West Kennebunk, Me.	1911	[1] 578	705	[1] 462.5	485	80	68.8	.1856	3,115	54.3	2,495	37.35	.....	.....	.....	
Dimond, O. C., West Concord, N. H.	1911	[1] 692	547	[1] 598	539	86.4	98.5	.1202	5,756	65	4,972	64	.....	.....	.....	Strong, stony loam, on top of hill sloping; dry until midsummer, later part of season wet.
Elmer, E. O., Devereaux, Mich.	1911	[1] 218	337	[1] 252	365.5	115.6	108.4	.0757	2,880	63.6	3,330	68.9	.....	.....	.....	Sandy loam, level; early part of season dry, later part wet.
Goddard, W. R., Amesville, Ohio.	1911	(1)	562	(1)	596	.....	106	.1234	.....	65	.....	68.9	.....	.....	.....	Limestone bottom, level; season very dry.
Hester, H. C., Mayfield, Ky.	1911	300	150	120	80	40	53.3	.3025	992	7.1	397	3.78	.....	.....	.....	Rolling land; season extremely dry.
Heuser, W. L., Haymarket, Va.	1911	[1] 182	223.5	[1] 168	254	92.3	113.9	.0804	2,263	39.7	2,089	45.25	.....	.....	.....	Sandy loam, drained bottom; early part of season dry.
Hill, L. E., Walterboro, S. C.	1911	.....	250	[2]	220	.....	88	.317	.....	11.26	.....	9.92	.....	.....	.....	Light soil, level; season dry.
Housekeeper, G. C., Bowling Green, Ohio.	1911	.....	681	[3]	675	.....	99.1	.1061	.....	91.7	.....	90.8	.....	.....	.....	Sandy loam, level; season very favorable.

[1] No difference in time of ripening. [2] Ripened earlier. [3] Ripened a few days earlier.

TABLE III.—*Results of experiments in corn tillage for the years 1905 to 1911, inclusive*—Continued.

Name and address of experimenter.	Year.	Yield per plat.				Yield of uncultivated plat expressed as percentage of cultivated.		Size of plat.	Yield per acre (calculated).				Precipitation.			Remarks.
		Cultivated.		Uncultivated.					Cultivated plats.		Uncultivated plats.		Last 3 months of preceding and first 9 months of current year.	Mean.	Comparison with mean.	
		Fodder.	Grain.	Fodder.	Grain.	Fodder.	Grain.		Fodder.	Grain.	Fodder.	Grain.				
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*			*Acres.*	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Ins.*	*Ins.*	*P. ct.*	
Huyett, J. B., Charles Town, W. Va.	1911	444.5	614	432	529	97.3	86.1	0.152	2,923	57.7	2,848	49.7	.....	.....	.....	Loam, clay subsoil; season fairly favorable.
Ladd, E. O., Old Mission, Mich.	1911	[1] 817	595	[1] 787	758	96.3	127.4	.2635	3,100	32.24	2,985	41.08	.....	.....	.....	Dark sandy loam, level; season cold, but enough rain.
Lambert F. L., Charles City, Iowa.	1911	(1)	180	(1)	180	.....	100	.0389	.....	66.1	.....	66.1	.....	.....	.....	Sandy loam, level; early part of season dry, later part wet.
Lemmon, R. H., Winnsboro, S. C.	1911	(1)	66	(1)	54	.....	81.8	.0275	.....	34.3	.....	28.05	.....	.....	.....	Fine sandy soil, rolling land; season very dry.
McClenden, S. E., Calhoun, La.	1911	.....	149	.....	140	.....	93.9	.0965	.....	22.06	.....	20.72	.....	.....	.....	Land almost level; good season, except dry in May.
McCulloch, Fred, Hartwick, Iowa.	1911	306	232	[2] 302	206	98.7	88.8	.0231	13,220	143.1	13,050	127	.....	.....	.....	Heavy black loam, level; season very dry.
Perry, J. B., Clarks Falls, Conn.	1911	278	182	198	156	71.2	85.7	.0442	6,290	58.8	4,480	50.4	.....	.....	.....	Loam, gravelly subsoil, level; extremely dry season.
Prince, A. H., San Augustine, Tex.	1911	(1)	216	(1)	216	.....	100	.1147	.....	26.9	.....	26.9	.....	.....	.....	Sandy loam, level; on top of hill; too wet to cultivate; then too dry.
Ransom, E. R., Blandville, Ky.	1911	10	52	[3] 10	48	100	92.3	.0138	724	53.8	724	49.7	.....	.....	.....	Rich clay in garden, level; dry and hot in summer.
Rector, J. H., Cumberland Gap, Tenn.	1911	.....	840	(2)	710	.....	84.5	.1808	.....	66.4	.....	56.1	.....	.....	.....	Clay loam, level; season very dry.
Seymour, R. R., Henning, Ill.	1911	.....	460	.....	380	.....	82.6	.1683	.....	39.05	.....	32.25	.....	.....	.....	Silt loam, level; May to August dry.
Smith, C. S., Nokesville, Va.	1911	[1] 61.5	70.5	[1] 58	67	94.3	95	.0301	2,040	33.41	1,925	31.75	.....	.....	.....	Clay, level; season very dry until July 20.

U. S. Plant Introduction Garden, Chico, Cal.	1911	212	86	[2] 181	74	85.3	86	.0482	4,418	25.52	3,770	21.95	.....	.....	.....	Sandy loam, level; season dry.
Total	.....	7,191	10,897	6,763.5	10,129.5	.....	.....	3.5745	60,591	1,281.74	56,764	1,191.9	.....	.....	.....	
Average	.....	479.4	435.9	450.9	405.2	91.24	92.37	.1429	4,039	51.27	3,784	47.67	.....	.....	.....	

[1] No difference in time of ripening. [2] Ripened earlier. [3] Ripened a few days earlier.

RÉSUMÉ OF THE CORN-CULTIVATION EXPERIMENTS.

Table IV presents a résumé of all the experiments. The yield of the uncultivated plat is expressed as a percentage of the yield of the cultivated plat. The average percentages shown in Tables I and III are here compiled for comparison. Of the total number of 125 tests whose data are recorded in this bulletin, 1 test shows fodder yields only, 54 tests show yields of both fodder and grain, and 70 tests show grain yields only. The data on grain yields are, therefore, given for 124 and on fodder yields for 55 of the total number of experiments. The general average for all the experiments shows that the fodder on the uncultivated plats was 95.1 per cent of the cultivated and that the uncultivated grain was 99.108 per cent of the cultivated.

TABLE IV.—*Résumé of average results of experiments in corn tillage.*

Designation of experiments.	Fodder.		Grain.	
	Number of experiments.	Average yield of uncultivated plats expressed as percentage of cultivated.	Number of experiments.	Average yield of uncultivated plats expressed as percentage of cultivated.
Early experiment station work (Table I)	2	85.35	12	98.5
1905 and 1906 (Table III)	3	96.36	5	108.4
1907 (Table III)	2	91.6	8	110.84
1908 (Table III)	4	94.95	6	97.93
1909 (Table III)	10	101.15	25	105.27
1910 (Table III)	19	96.19	43	96.51
1911 (Table III)	15	91.24	25	92.37
Total	55		124	
General average		95.1		99.108

GEOGRAPHICAL DISTRIBUTION OF THE EXPERIMENTS.

Figure 8 shows the distribution of the experiments in the various States. It will be noted that the conditions of soil and climate under which the tests were made are quite varied. The total number of experiments recorded in the summary is 125 and the number of States represented in this work 28. In Table V the location of the experiments by States is correlated with the average yield of grain from the uncultivated plats expressed as a percentage of the average yield of grain from the cultivated plats.

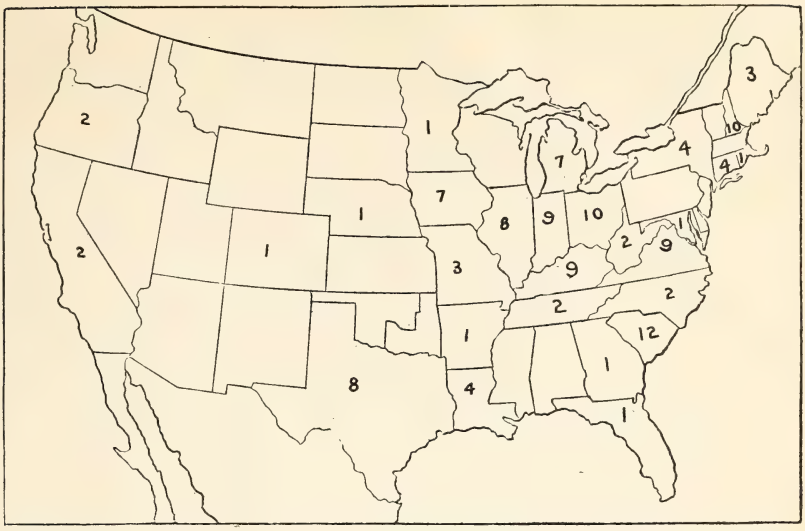

FIG. 8.—Map showing the distribution of the corn-cultivation experiments in the various States.

TABLE V.—*Relative grain yield by States.*

State.	Number of experiments.	Average yield of uncultivated plats expressed as percentage of cultivated.	State.	Number of experiments.	Average yield of uncultivated plats expressed as percentage of cultivated.
Arkansas	1	77.4	Missouri	3	103.2
California	2	86.8	Nebraska	1	101.9
Colorado	1	90.1	New Hampshire	10	112.71
Connecticut	4	98.8	New York	4	104.7
Florida	1	87.1	North Carolina	2	92.15
Georgia	1	138.8	Ohio	10	96.17
Illinois	8	94.74	Oregon	2	99.3
Indiana	9	105.36	Rhode Island	1	89.6
Iowa	7	102.72	South Carolina	12	99.07
Kentucky	9	91.28	Tennessee	2	89.4
Louisiana	4	105.8	Texas	8	92.59
Maine	3	77.9	Virginia	9	88.51
Maryland	1	109.2	West Virginia	2	77.9
Michigan	7	116.26			
Minnesota	1	100	Total	125	

RELATIVE MATURITY OF CULTIVATED AND UNCULTIVATED CORN.

In 1909, 1910, and 1911 the cooperators were asked to report which of the two plats or sets of plats matured first. Note of this matter was made by 68 of them, 39 of whom reported no difference in the date of ripening, while 10 stated that the cultivated plats ripened first and 19 stated that the uncultivated plats were first to ripen. The average grain yield from the uncultivated plats expressed as a percentage of the yield from cultivated plats in these three groups is approximately 100 per cent for the first two groups and 95.58 per

cent for the third group. These results are shown in Table VI, and they seem to indicate that when for any reason the uncultivated plat falls below the cultivated plat in yield the uncultivated corn has a tendency to mature earlier than the cultivated corn.

TABLE VI.—*Relative time of maturity of cultivated and uncultivated corn.*

Relative time of maturity.	Number of experiments.				Average grain yield of uncultivated expressed as percentage of cultivated.
	1909	1910	1911	Total.	
Cultivated ripened first	3	7	0	10	100.36
No difference in time of ripening	11	18	10	39	101.68
Uncultivated ripened first	3	9	7	19	95.58
Total	17	34	17	68	

RELATION OF CORN-TILLAGE RESULTS TO RAINFALL.

In the annual charts of the experiments, with the exception of the year 1911, for which the data are not yet available, are given the actual rainfall, the mean rainfall, and the actual rainfall expressed as a percentage of the mean. As previously stated, this rainfall is for the last three months of the previous year and for the first nine months of the year in which the experiment was conducted. Rainfall data are available for 95 of the 124 experiments. Of the whole series of experiments the lowest rainfall with reference to mean was 42 per cent and the highest 133 per cent. In two experiments a rainfall of over 120 per cent of the mean was recorded, while in three experiments the rainfall was less than 60 per cent of the mean. Working out the relation between the yield of the uncultivated plats expressed in percentage of the yield of the cultivated plats and the rainfall expressed in terms of percentage of the mean rainfall, there was found to be a correlation of only 0.142 ± 0.065, which can not be considered significant.

In actual rainfall the lowest precipitation for any experiment was 16 inches for the year and the highest 61 inches. The greater number of the experiments upon which rainfall data are presented received from 30 to 40 inches of rain for the period. Working out the correlation between the yield of the uncultivated plat, expressed in percentage of the cultivated, and the actual rainfall, there was found to be a correlation of only 0.0188 ± 0.067.

These data do not indicate that rainfall enters into the problem to any appreciable extent

RELATION OF CORN-TILLAGE RESULTS TO SOIL PRODUCTIVITY.

The results of all the tillage experiments were studied with the object of determining whether the factors which influence grain yield had any effect on the yield of uncultivated corn as compared with the cultivated. For this purpose the experiments were considered in three groups: Group 1, containing those experiments in which the yield on the cultivated plats fell below 30 bushels per acre; group 2, those varying from 25 to 60 bushels; and group 3, those above 50 bushels. By thus overlapping the limits of the various groups it was thought that tendencies would be shown more clearly than if absolute limits were observed.

Little evidence is shown that any relation exists between these two factors. Group 1, containing the lowest grain yields, shows the average yield on the uncultivated plats to be 97.19 per cent of that on the cultivated; group 2 shows 99.59 per cent; and group 3 shows 98.34 per cent. The details are given in Table VII.

TABLE VII.—*Relation of corn-tillage results to soil productivity.*

Year.	Experimenter.	Yield of cultivated plat per acre.	Yield of uncultivated plat expressed as percentage of cultivated.	Year.	Experimenter.	Yield of cultivated plat per acre.	Yield of uncultivated plat expressed as percentage of cultivated.
	GROUP 1.—*Yields less than 30 bushels per acre.*				GROUP 2.—*Yields between 25 and 60 bushels per acre.*		
1906..	New Hampshire experiment station	*Bushels.* 23.3	141.6	1886..	New York experiment station (Geneva)	*Bushels.* 56.8	**124.1**
1908..	North Carolina experiment station	11.55	92	1890..	Missouri experiment station	54	84.6
1909..	Callison, N. A	25.3	87.1	1891..	Illinois experiment station	58.4	94.7
	Campbell, J. M	12.2	66.8	1893..	do	36.3	79
	Cunningham, T. J	22.5	115	1898..	South Carolina experiment station	58.6	96.4
	Foster, W. L	16.6	114.7	1906..	Purdue experiment station	46.97	95.9
	Rich, E. A. J	26.7	138.8	1907..	Cornell experiment station	50.3	103.4
	Seay, Robert	29.7	80.6	1908..	Arlington Experimental Farm	41.4	97.7
	Sugar Experiment Station	20.6	100	1909..	Anderson, W. B	48.1	136.5
	Wollschlaeger, Gus	19.2	101.7		Barrett, J. M	52.2	123.7
1910..	Campbell, J. M	24	107.1		Arlington Experimental Farm	30.6	74.1
	Crum, H. C	21	114.3		Callison, N. A	25.3	87.1
	Ferguson, A. M	5.67	95.9		Lambert, F. L	56.4	115.3
	Gardner, E. T	16.2	90.1		Leffler, G. V	40.5	109.6
	Howle, P. L	15	97.1		Perry, J. B	45.7	108.7
	Marvin, Jas. A	23.9	104.2		Purdue experiment station	42	100.25
	McClelland, C. K	10.37	77.4		Rich, E. A. J	26.7	138.8
	U. S. Plant Introduction Garden	12.4	87.6		Seay, Robert	29.7	80.6
	Wollschlaeger, Gus	23.78	99.3		Tenney, W. P	31.25	170.5
1911..	Hester, H. C	7.1	53.3	1910..	Bigstaff, T. J	37.65	96.6
	Hill, L. E	11.26	88		Day, A. P	47.9	87
	McClendon, S. E	22.06	93.9		Finley, W. W	48.8	92.3
	Prince, A. H	26.9	100		Fredericks, C. P	50.14	106.4
	U. S. Plant Introduction Garden	25.52	86				
	Average		97.19				

TABLE VII.—*Relation of corn-tillage results to soil productivity*—Continued.

Year.	Experimenter.	Yield of cultivated plat per acre.	Yield of uncultivated plat expressed as per centage of cultivated.
	GROUP 2.—*Yields between 25 and 60 bushels per acre*—Cont'd.		
		Bushels.	
1910..	George, H. C	55.4	90
	Heuser, W. L	48.9	82.4
	Huyett, J. B	33.1	69.7
	Kirkpatrick, L. R	38	68.4
	Lambert, F. L	55	100
	Lemmon, R. H	47.9	100
	Perry, J. B	42.45	100.9
	Ratliff, W. S	42	123.9
	Ross, Henry	30.9	99
	Royce, Oscar	49.65	111.2
	Sugar Experiment Station	30.5	114.7
1911..	Brant, W. C	33.5	104.4
	Dailey, S. C	38.5	93.3
	Day, A. P	54.3	68.8
	Heuser, W. L	39.7	113.9
	Huyett, J. B	57.7	86.1
	Ladd, E. O	32.24	127.4
	Lemmon, R. H	34.3	81.8
	Perry, J. B	58.8	85.7
	Prince, A. H	26.9	100
	Ransom, E. R	53.8	92.3
	Seymour, R. R	39.05	82.6
	Smith, C. S	33.41	95
	U. S. Plant Introduction Garden	25.52	86
	Average		99.59
	GROUP 3.—*Yields more than 50 bushels per acre.*		
1886..	New York experiment station (Geneva)	56.8	124.1
1888..	Illinois experiment station	93.8	95.9
1889..	....do	84.6	91.1
1890..	....do	66.8	103.4
1891..	....do	58.4	94.7
1892..	....do	70.1	109.5
1896..	....do	85.5	101.7
1889..	Missouri experiment station	80.1	101.3
1890..	....do	54	84.6
1898..	South Carolina experiment station	58.6	96.4
1899..	....do	67.3	100.3
1907..	Cornell experiment station	50.3	103.4
	Froley, J. W	65.3	109.2
	Nebraska experiment station	61.9	101.9
	Purdue experiment station	77	103.7

Year.	Experimenter.	Yield of cultivated plat per acre.	Yield of uncultivated plat expressed as per centage of cultivated.
	GROUP 3.—*Yields more than 50 bushels per acre*—Cont'd.		
		Bushels.	
1908	Minnesota experiment station	62.5	100
	New Hampshire experiment station	67.9	100.4
	Purdue experiment station	62.5	96
1909	Barrett, J. M	52.2	123.7
	Dimond, O. C	62.4	121.1
	Lambert, F. L	56.4	115.3
	Lee, J. J	81.3	96
	Littlejohn, W. D	73.8	95.3
	McCune, Kate B	107.4	106.3
	Merwin, G. H	78.4	100
	Sawyer, R. S	71.3	69.1
	Wallace, M	84.9	91.9
	Watson, A. D	67.4	99.1
	Welch, E. K	64.2	109.7
1910	Anderson, W. B	62.6	99.2
	Brant, W. C	70.3	95.5
	Case, J. H	65	107.7
	Dailey, S. C	83.1	89.2
	Dimond, O. C	90.6	90.9
	Elmer, E. O	85.6	101.8
	Fredericks, C. P	50.14	106.4
	George, H. C	55.4	90
	Goddard, W. R	84.9	93.3
	Hansbarger, D	105.4	99.4
	Hester, H. C	74.1	84
	Lambert, F. L	55	100
	Lloyd, F. L	63.5	101.6
	McCune, Kate B	65.2	92.3
	Morgan, Geoffrey	98.1	116.3
	Rector, J. H	139.7	94.3
	Rinehart, N. W	104.6	84.2
	Welch, E. K	70.5	126.2
	Williams, D. W	106.2	100.8
	Winsor, B. E	72.9	89.6
1911	Anderson, W. B	74.3	97.5
	Arlington Experimental Farm	78.4	73.9
	Day, A. P	54.3	68.8
	Dimond, O. C	65	98.5
	Elmer, E. O	63.6	108.4
	Goddard, W. R	65	106
	Housekeeper, G. C	91.7	99.1
	Huyett, J. B	57.7	86.1
	Lambert, F. L	66.1	100
	McCulloch, Fred	143.1	88.8
	Perry, J. B	58.8	85.7
	Ransom, E. R	53.8	92.3
	Rector, J. H	66.4	84.5
	Average		98.34

SIMPLIFICATION OF WEED CONTROL WHEN THE SOIL IS NOT STIRRED.

A very interesting observation made during these investigations is that with some of the experiments on certain soils weeds ceased growing on the uncultivated plats sooner than on the cultivated ones, where the number of hoeings and cultivations, respectively,

was the same; so that at harvest time the uncultivated plats were quite free from weed growth and the cultivated plats were more or less weedy. An example of this is shown in figure 9, which illustrates a carefully conducted experiment on a rather stiff clay soil at the Arlington Experimental Farm. On the uncultivated plats of this experiment the weeds started growing immediately after planting to about the same extent as on the cultivated plats. But as the season progressed and the weed seeds in the surface inch or two of soil germinated and the seedlings were destroyed, the weed growth became gradually less, while on the cultivated plats the weeds continued to grow thriftily throughout the season. This tendency was shown in a number of experiments on soils of this kind. The reason for this may

FIG. 9.—Two plats at the Arlington Experimental Farm, the cultivated at the left and the uncultivated at the right, showing the difference in weed growth under the two methods of treatment.

be due to the condition of the soil on the uncultivated plats discouraging germination of weed seeds beneath the surface inch or two and the inability of the seedlings to push up through the hard crust, whereas on the cultivated plats the friable surface soil permitted the seedlings to push up from a considerable depth and the tillage implements were constantly bringing up weed seeds into the surface soil where conditions were more conducive to germination.

It was observed that on other soils, however, especially those of a loose, deep, moist character, the weed growth on the two sets of plats was about the same throughout the season.

Whether or not it is desirable to discourage the germination of weed seeds can not be stated definitely at the present time. It may be

argued on the one hand that the crop should be so tilled as to induce the germination of as many of the weed seeds as possible, with the subsequent destruction of the seedlings. On the other hand it may be argued that under the conditions that existed on the nontilled plats of these experiments, although a much smaller proportion of weed seeds in the soil was induced to germinate, many of those that remained ungerminated probably lost their viability and that as there was a much smaller number of weeds on these plats than where the land was tilled a correspondingly less number of weed seeds matured to reseed the land in the latter part of the season after cultivation stopped.

It must be understood that there are no data to prove which of the two opinions stated above is the correct one. It is impossible to say, therefore, which of the two methods of treatment would be the less conducive to weediness of the soil through a period of years during which different crops were grown. The observations on these experiments, however, seem to indicate that for the years in which the land is in cultivated crops the work of weed control may be considerably simplified by shallow rather than deep working of the soil.

FAIRNESS OF THE TESTS.

Although the weed growth seemed to be less on the uncultivated plats than on the cultivated ones in some of the experiments, there were others where the surface scrapings or hoeings were not sufficient to keep down the weeds as thoroughly on the uncultivated plats as on the cultivated ones. It is believed, therefore, that on an average for all experiments the weed growth under the two kinds of treatment was about the same in extent, but that if there was any difference in this regard there were more weeds on the uncultivated than on the cultivated plats—due to the fact that some of the cooperators did not do as thorough work in keeping down weeds on the uncultivated plats as on the cultivated ones.

Another point which may have affected the fairness of the tests was that where the experiments were located on sloping land there was a tendency for rain water (especially at times of heavy rains) to run off the uncultivated plats to the adjoining cultivated ones, where it was caught and allowed to soak in the soil, on account of the rough and absorptive condition of its surface, so that the cultivated plats received more than their share of the precipitation.

Altogether, if there was any advantage in favor of either of the sets of plats it was on the side of the cultivated ones.

RELATION OF TESTS SHOWN BY FREQUENCY CURVE.

The frequency curve (fig. 10) shows that the results secured are not of a mere haphazard nature. Of the total number of experiments 46 per cent give results between 92.5 and 107.5 per cent of uncultivated grain in terms of the cultivated. These limits come well within the bounds of experimental error. The general average,

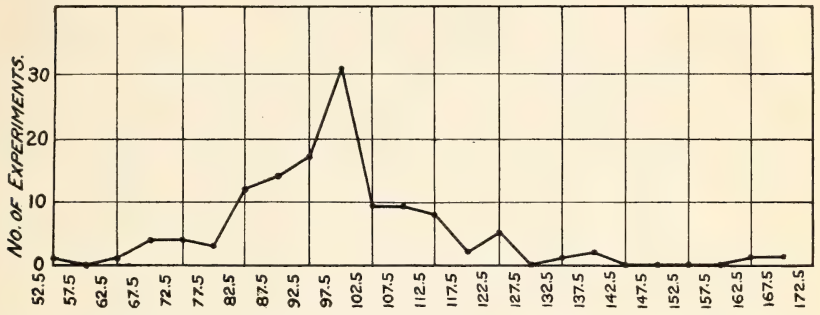

FIG. 10.—Diagram showing the yields of uncultivated plats of corn expressed in percentages of yields of cultivated plats for 124 experiments in 28 States.

therefore, of the whole 124 tests, showing 99.108 per cent as much grain produced on the weeded plats as on cultivated plats, is significant.

INTERPRETATION OF THE RESULTS OBTAINED.

The reasons why uncultivated land kept free from weeds should yield practically as much corn (grain) per acre as that given the most approved modern cultivation are not clear. The results, however, point strongly to the conclusion that the principal object of cultivation is the destruction of weeds. Where the weeds are kept down by some other method cultivation seems to be of no particular advantage. This is contrary to the accepted teaching on this point, and the conclusion is stated only tentatively. There have been abundant experimental results to show that when land is fallow a soil mulch upon it tends to preserve the moisture in the soil. It appears quite possible that when the soil is fully occupied by the roots of a growing crop there is little possibility of moisture from the deeper layers of the soil being drawn by capillary action to the surface, where it could be evaporated, for in doing so the moisture would have to thread its way through a maze of roots eager to absorb it. Does it not seem that these roots would themselves play the part that a soil mulch would play if the roots were not there? If such is the case, what additional advantage would arise by having a mulch

on a surface beneath which is a tangle of fine roots capable of absorbing any moisture that might try to pass upward to the surface?

On the other hand, these roots would not interfere to any great extent with the progress of rain water downward in the soil, for when rainfall is great enough to saturate the surface soil there would be more moisture present than the roots could absorb. Thus, while the soil mulch is important on fallow soils as a means of holding moisture, is it not possible that a soil well filled with living plant roots is not in need of a mulch for this purpose? This would at least be a plausible explanation of the results reported in this bulletin.

It is further suggested that these results may partly be due to the fact that tillage mutilates the surface roots of the crop. Again, a fall of rain too light to moisten the soil below the depth of stirring would all be lost on the cultivated land because it would not reach the roots of the crop, while on the weeded plat there would be enough roots in the surface soil to absorb a considerable proportion of such light rainfall before it had time to evaporate.

While the suggestion that the presence of a maze of living roots in the soil would itself, to a large extent, prevent loss of moisture by evaporation at the surface, it is not proved that this is the case. We must therefore consider other possibilities. Even with ordinary methods of cultivation there would be some loss of moisture at the surface, for tillage itself would expose a large amount of moist soil to the atmosphere, so that in any case a growing crop would hardly utilize all the rainfall that occurs during a growing season. If, however, the loss of moisture by evaporation is greater on the uncultivated plats than on the cultivated ones it is possible that this would be compensated for by a correspondingly greater amount of nitrates and other soluble salts being brought up from the deeper layers of the soil to the surface, thus furnishing a greater quantity of plant food for the corn roots.

It should be clearly understood that the writers offer these remarks merely as suggestions. The underlying causes for the phenomena observed must be left for future determination.

PRACTICAL SIGNIFICANCE OF THE RESULTS.

An explanation of the results obtained in these experiments is of secondary importance as compared with the interpretation we shall give them from a practical standpoint. The results as a whole come well within the limits of experimental error, showing no more difference in yield between the weeded plats and those receiving normal cultivation than might be expected between two series of 125 plats treated exactly alike.

Table V shows the results of the experiments by States. As only a small number of experiments have been conducted in some States, it is probable that another set of tests would show considerable difference in results in many localities. It would not be advisable, therefore, to make practical suggestions for any particular locality based on the indications of these results as a whole without first making actual tests to see whether under local conditions these same principles will govern. Where these results are found to hold good, however, two entirely new fields of research are opened up, and their practical importance to the corn growers of America from a labor and money saving standpoint is not to be gainsaid.

If it be true that weeds make the cultivation of corn necessary the problem immediately presents itself as to what farm-management methods can be pursued to eliminate or reduce to a minimum the weed pests of the farm. In this connection we have (1) the problem of what may be termed persistent perennial weeds. Among this group may be mentioned Johnson grass, quack-grass, Bermuda grass, wild morning-glory, Canada thistle, wild onion, and horse nettle. Publications already issued by the Department of Agriculture deal with the control of these pests. In the main these weeds require special treatment to eradicate them. We have (2) the biennial and annual weeds, which are troublesome largely through their prolific seed habits. As a class these weeds should be prevented from going to seed until all the seeds infesting the land shall have germinated and the seedlings have been destroyed.

Our present implements for cultivation are designed primarily to produce a mulch and stir the ground. Weed killing is a secondary function. It is possible that newly designed implements made with special reference to weed control could accomplish this end with greatly decreased cost. The weeder will probably be considered of vastly more importance than heretofore when more data with reference to its use are available.

Another large field of investigation in connection with weed control is of much practical importance to the farmer. This field of work might be outlined as a study of those systems of farming or rotations which are especially calculated to lessen the weed pests on the farm. It is a well-known fact that certain rotations of crops bring us round to the tillage crop with the land practically free from weed pests. One experiment is reported where a piece of sod land very free from everything but clover and timothy was put to corn and no cultivation given, as no weeds were present; a crop of 70 bushels per acre was produced. In some sections of the South, where a 1-year rotation of corn and crimson clover is practiced, the weeds are reduced to a minimum and many farmers cultivate corn on such

land only once and secure large yields. Studies are being conducted on this problem of adapting cropping systems to weed control, and more data will be at hand at a later date.

Just what implements are best to destroy weeds when present and just what rotations should be practiced to control them are largely local problems. Each State or agricultural region will have its own answer. In those cases where a soil mulch may be desirable it will undoubtedly be true that any tillage implements designed primarily to kill weeds will incidentally produce a sufficient soil mulch to answer all requirements in this respect.

The writers interpret the results here presented to mean that weeds are in the main the enemy which makes cultivation necessary. The exceptions should be determined by further work. Weeds can be fought from two standpoints: (1) With tillage implements specially designed to kill these pests instead of to stir the soil and make a mulch and (2) from the standpoint of rotations especially designed to overcome the weeds of the particular locality. It is believed that by adopting methods in conformity with this point of view the weed problem will be simplified and in all probability the cost of cultivation will at the same time be greatly decreased.

SUMMARY.

A number of tests made at several agricultural experiment stations seem to indicate that it is the weed factor that makes the cultivation of corn necessary, or, stating the proposition conversely, that cultivation is not beneficial to the corn plant except in so far as removing the weeds is concerned.

The subject of weed control is recognized as a fundamental one in tillage philosophy. It was therefore determined to carry on, over a wide range of climatic and soil conditions, a large number of tests of the relative yields of corn produced by supposedly optimum cultivation as compared with mere weed elimination.

The experiments were made by having two plats or sets of plats, one of which received no cultivation after planting, the weeds being kept down by a horizontal stroke of a sharp hoe at the surface of the soil, particular care being taken not to disturb the soil or to form a soil mulch; the other set of plats received the usual cultivation.

This work was carried on by the Department of Agriculture for six years (1906 to 1911) in cooperation with several State agricultural experiment stations and with farmers, many of whom were graduates of agricultural colleges. The results of 125 experiments are recorded in this bulletin, including the early experiment-station tests. The seven years' work in Utah is given separate discussion. Of the 125 experiments 124 record grain yields and 55 give fodder yields.

A general average of all of these experiments shows that the weeded plats produced 95.1 per cent as much fodder and 99.108 per cent as much grain as the cultivated ones. If there was any difference between either set of plats in regard to thoroughness in keeping down weeds it was in favor of the cultivated plats.

Although it remains to be demonstrated how far this principle may be applied in any particular section, as a general average for all the regions in which this work was done it may be concluded that the proposition just stated is substantially true. If this be accepted, weed control becomes the principal object of cultivation.

Weeds may be attacked in two ways: (1) By the use of tillage implements, the primary purpose of which is their eradication, and (2) by adopting cropping systems having that object in view.

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